THE 1958 MIGRATION OF THE PAINTED LADY BUTTERFLY, VANESSA CARDUI (LINNAEUS), IN CALIFORNIA

(Lepidoptera: Nymphalidae)

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The most recent migration of the painted lady butterfly, *Vanessa cardui* (Linnaeus), was particularly notable for its long duration, from November, 1957 through May, 1958. Observations on this migration have yielded rather definite information on several doubtful points and are the subject of this paper.

The previous reports by the present author on the migration of this species (Abbott, 1950, 1951), based on the migrations of 1924, 1926, 1941, 1945, and 1949, determined various points which will be referred to here only incidentally. It became apparent from these studies that the breeding area of this species, in non-migration years, is chiefly, if not entirely, south of the California-Mexico border, probably in both Baja California and Sonora. Comparatively few of the butterflies are found in California in a non-migration year, and these few chiefly in the Colorado Desert. In a migration year the number emerging in these breeding areas is presumably much greater. One result is a very visible diurnal migration, in a generally north-northwest direction, covering southern California and in some years north to the San Francisco Bay region. Yet the final eggs laid in these regions where it is an immigrant fail to result in a permanent occupation of this more northern habitat.

As in the preceding studies, the present report results from a cooperative study; in this case with the added advantage that most of the contributors are professional entomologists. Thanks to the continued interest of R. F. Smith in collecting data for the project, valuable contributions were secured from the following members of the staff of the Department of Entomology and Parasitology, University of California, Berkeley: P. D. Hurd, Jr., E. G. Linsley, J. W. MacSwain, R. F. Smith, W. E. Ferguson, J. A. Powell and from the following members of the Agricultural Extension Service: G. Beards, J. Dibble, R. Emparin, G. L. Smith, J. E. Swift. I am also indebted to R. C. Dickson of the Citrus Experiment Station, University of California, Riverside, and G. D. Peterson, Jr., Farm Adviser for Imperial County, for descriptions of the winter and early spring invasion of the

Colorado Desert, and to C. E. Strickler, Park Supervisor, and D. E. Merkel, State Park Naturalist, for data for the entire season from Anza-Borrego State Park. L. M. Martin of the Los Angeles County Museum has been helpful with both data and criticisms. Credit for individual contributions will be indicated in the text. It should be understood that the author alone is responsible for the conclusions drawn from the data.

The present status of our knowledge of insect migration in general and of Lepidoptera in particular is summarized in two recent papers by Williams (1949, 1957). The word "migration" is defined by Williams (1949) as "a change of location which is determined both in distance and direction by the insect itself, and not a passive distribution of individuals by overpowering forces such as strong winds."

The present year, 1958, has presented a picture of a longer continuing migration than any other in recent years. The season was mild, with early rainfall resulting in extensive desert vegetation. Butterflies of this species emerged very early in their normal breeding areas in northern Mexico in such numbers as to result in migration. Numbers of them had already reached the southern part of Anza-Borrego State Park by November, 1957 (Merkel), and Imperial Valley by late December (Peterson). Peterson wrote: "As near as I could determine from actual flight observations plus population density counts, the butterflies seemed to be migrating generally from the desert areas south and east of Imperial County and toward the north and northwest."

Dickson wrote: "I first noticed the migration of painted lady butterflies about the last week of January or possibly the week before that. About that time I heard that automobiles coming into Holtville from Yuma had the radiators practically clogged by these butterflies. They were moving out of Sonora, flying northwest to west, and more particularly numerous near Carpinteria. . .

"The painted ladies have laid eggs on suitable host plants (particularly *Cryptantha* and *Malva*) all over the deserts and desert valleys. Large numbers of larvae are now (March 17) feeding on these plants all over the Colorado Desert so that this area may be a source of a later flight this season."

The emergence of second generation adults from these metamorphosed larvae was recorded in February in Imperial County

by Peterson, who concluded that they joined the general migration which had been proceeding without interruption, and in Borrego State Park by Merkel, who described increasing large swarms somewhat farther north than the November–December emergence, but did not observe the actual migration.

The height of the migration in the valleys of southern California was in late February and early March. Under date of March 17, Dickson wrote: "There has been some flight through Riverside the past three weeks, but greater numbers flew through Beaumont, Redlands, and Colton. Presumably others flew over the Mojave Desert since I hear that some have reached the San Joaquin Valley. I did not see any flight this week either on the desert or in Riverside. This might indicate that the flight is over for this year, or only that the cold weather has slowed emergence of new butterflies in their areas of origin." During this period the "Redlands Facts" reported that "endless swarms" were flying through Redlands.

The "Los Angeles Times" reported on March 5 and 6 that a "great invasion" had occurred in the Los Angeles area March 2–4. Particular mention was made of Hollywood, the Hollywood hills, and the San Fernando and San Gabriel Valleys. The author observed that they were still common at San Fernando, although not in "millions," on March 18 and 19. Many of them were stopping to feed on wild radish flowers in vacant lots, before continuing their flight to the north-northwest.

The western edge of this February–March migration was recorded by the author at Redondo Beach. Individual *V. cardui* were observed on garden flowers on January 4, 16, February 5, 19, 26, 27, March 9, 29; actual migrating butterflies were observed February 21, daily March 1–6, 11, 16. The migration was steady March 2–4, one or two per minute, the same days as the maximum in Los Angeles.

After an interval in late March and early April, which was marked by cold and rainy weather, a heavy migration wave occurred in the middle of April in the San Joaquin and Salinas Valleys. Summarized in brief:

San Joaquin Valley.—Heavy migration throughout valley from south and east of Bakersfield to the region west and north of Tracy. First flight recorded April 8, at height April 10, 11, began to decline April 17, moderate flight April 20, a few stragglers

April 23 (R. F. Smith, Hurd, Linsley, MacSwain, Ferguson). Stragglers to May 9 (R. F. Smith, Swift).

On April 13 they were abundant near Mt. Diablo (R. F. Smith). On April 20 there was a heavy flight in the Walnut Creek region (R. F. Smith, Swift).

Salinas Valley, April 17.—Migration reported (Dibble, Emparin).

The author made one observation of three migrants at Redondo Beach on April 19, but has no other report of this third generation from the Los Angeles area.

Larvae, presumably from eggs laid by these April migrants, were so abundant in the San Joaquin and Salinas Valleys from about April 20 to May 9 that they were found not only on wild plants, but damaging alfalfa, lettuce, and other crops (R. F. Smith, Swift). They were also abundant in clover fields in Glenn County, farther north (reported by R. F. Smith). At Shafter, near the southern end of San Joaquin Valley, the larvae were abundant from about April 10, and in some cases caused enough damage to cotton fields to require control measures (G. L. Smith, Beards).

The above description shows an apparent pattern of a built-up migration through three generations rapidly succeeding each other. Most published descriptions of former spring migrations of this species have assumed that the migrating adults were all of one generation and in general from a common source. This has applied not only to migrations in California and Utah, but also to those in Europe. Campbell (1924) in California and Woodbury *et al.* (1942) in Utah described egg-laying along the way, with the possibility that a new generation from these eggs took part in a later migration the same year. It has, however, seemed more usual that the larvae from these eggs either did not develop to the adult stage, or, because of the smaller numbers, their presence or possible later flight went unnoticed, except in rare instances.

The interpretation of numbers of generations involved is complicated by the apparent great variation in the length of the egg, larva, and pupa stages. L. M. Martin, after checking the literature, wrote me (June 19, 1958): "As far as I can find out, there are no figures on the length of these stages. We know that they vary, for instance, in the egg stage from 7–60 days. The

larval stage varies from 13–41 days and the pupae have been known to stay in that stage for eight months."

The most distinct three generation pattern is found in the records of D. E. Merkel, State Park Naturalist at the Anza-Borrego State Park. As a background, Merkel notes that in the period 1956–57, prior to November 1, 1957, no painted ladies were observed in the park. "If any were present, they were in such small numbers as not to attract attention." This appears to eliminate the Park as part of the breeding area in non-migration years.

As the earliest record of the 1958 migration, large swarms were first noted in November, 1957, in the Mud Hills region in the southern part of the Park. They had apparently emerged farther south, probably in northern Mexico, and had flown north to this secondary breeding area. The subsequent history is as follows: January, 1958, in same Mud Hills region, many pupal casts. February, 1958, at Borrego Campground area, about 25 miles farther north, increasing large swarms of adults. March, 1958. Larvae numerous throughout Borrego Valley, some beginning to pupate. April, 1958. Adults numerous in valley. Empty pupal cases abundant, probably of this species (also noted by Ferguson).

The above summary shows at least three generations. The November generation probably came from last year's eggs in the normal breeding area in northern Mexico, following a long pupal stage during the summer and fall. The second began to emerge in late January, reaching a maximum in February, and the third began to emerge in late March, reaching a maximum in April.

The first and second of these generations were also observed by Peterson in Imperial Valley. He recorded a steady migration from about December 20, lasting six or eight weeks, corresponding to the November and February periods of adult abundance reported by Merkel. Peterson thinks it is probable that two generations of larvae were abundant on desert hosts (mainly *Cryptantha* spp.) during this period, although, because of continuous migration, he could not separate them. "There may have been an extremely small third generation in the cultivated area of Imperial Valley, but this is in doubt." The decrease in numbers could have been caused by most of the second generation adults

migrating before egg laying, or by a drying up of the food-plants of the second generation larvae, or, as Peterson suggests, parasitism of the larvae may slow down the numbers of each successive generation.

The timing suggests that these second generation migrants are those reported as numerous through the San Gorgonio Pass and San Bernardino Valley regions in February and which were numerous in the Los Angeles region in early March. These reached the San Joaquin Valley, laid eggs, and from the eggs came the very abundant migrants observed throughout the valley in the middle of April. (Linsley and MacBride noted that these migrants seemed to be nearly all fresh specimens). Also belonging to this same third generation were those reported from Salinas Valley April 17, Mt. Diablo April 13, and Walnut Creek April 20.

It is not so easy to interpret the observations made in the desert in April, but the time element is again used. The names of the observers are given, the assignment to generations is by the author.

Colorado Desert, 18 miles west of Blythe, April 14–18.—Enormous numbers of hatched and parasitized pupae (eggs laid by second generation). Few adults left (Hurd, Powell). Most of the adults which had emerged must have flown north-northwest (third generation).

Borrego Desert, April 11–18.—Emerged pupae (eggs laid by second generation) abundant. Adults abundant, but not seen to be migrating (third generation) (Ferguson, Merkel).

Eastern Mojave Desert, April 12, near Amboy.—Pupae abundant, not emerged (eggs laid by second generation). Some worn adults, which had probably flown from farther south. A few adults near Topock, Arizona April 14 (Linsley, MacSwain).

Western Mojave Desert, April 12, 13, 14, 19.—Mature larvae abundant (eggs laid by second generation). Some adults migrating (third generation) (Hurd, Powell, Linsley, MacSwain).

These interpretations as to the principal generations involved do not eliminate the probability that some members of each generation flew farther than the ones here described, either before depositing eggs or afterwards. The timing best fits the basic interpretation here given, but there is probability of an overlapping of generations in each locality.

The larvae from eggs laid by the third generation were those

found so abundant in the San Joaquin and Salinas Valleys from about April 20 to May 9 that they were transferring from weeds to vegetables. Larvae found at the same time in Glenn County showed that adults of the third generation had reached there. This appears to show that it was the third generation larvae which were in such numbers as to be considered destructive, although it may be because these reports were from regions which have extensive field crops.

Reports of a fourth generation and on the final extent of the 1958 migration are fragmentary. J. A. and F. C. Powell collected *V. cardui* in Siskiyou and Del Norte Counties on seven scattered dates between June 23 and August 29, while G. Pitman found them on September 12, also in Siskiyou County. Specimens appeared fresh on June 24, 26, July 9, 18, August 4. This suggests continuation of the migration to the Oregon border and at least a fourth generation.

Based on preceding years of observation, it may be predicted that there will be no increase in resident population of *V. cardui* in 1959 in the regions invaded. The population control is discussed below under parasitism of larvae.

The butterfly *Vanessa cardui* (Linnaeus) received its specific name from the thistle, and is commonly thought to lay its eggs chiefly on thistles. But in California, where thistles are not particularly abundant, other plants appear to be just as acceptable as food plants for the larvae. This year's observations emphasize a number of these, as follows:

Colorado Desert: *Cryptantha* spp. (Peterson).
Colorado Desert: *Cryptantha, Malva* (Dickson).
Mojave Desert: *Cryptantha, Amsinckia, Phacelia* (Hurd, Powell).
Mojave Desert: *Cryptantha*, lupine, mallow (Linsley, MacSwain).
San Joaquin Valley: *Amsinckia.* Alfalfa, lettuce, and other crops (Swift).
San Joaquin Valley: *Malva, Amsinckia,* sunflowers, weeds, cotton (G. L. Smith, Beards).
Glenn County: Yellow star thistle, *Amsinckia,* dock (reported by R. F. Smith).
Salinas Valley: Nettle, lettuce (reported by R. F. Smith).

This shows that a considerable variety of wild plants are utilized and that in a year of special abundance, cultivated crops may be attacked. This favors large succeeding generations in the same year and continuation of migration.

The causes of a population increase resulting in a heavy

migration have already been enumerated to include a mild winter, a large amount of rainfall, and consequent abundant desert vegetation. In addition, in 1958, an unusually long favorable season has resulted in a build-up of population through at least three generations in one spring, with migration occurring in all of them. Yet it is almost an axiom that such a migration does not result in colonizing new areas or in increasing the permanent population in the areas reached. Possible checks are too rigorous a winter climate, effective toward the north, drying up of the food plants on which eggs are laid, effective toward the south and in arid climates, and control by parasitic attack. This last point will be discussed further.

Elton (1927), after extensive studies of population control, concluded that the most effective end of an outbreak or plague, whether resulting in a migration or not, is caused by some form of parasitic attack.

Schrader (1928) emphasized that *Vanassa cardui* (L.) is subject to the attacks of "a considerable number of parasitic wasps and flies." Essig (1926) in his section on Tachinid flies, names three species, *Zenillia blanda, Frontina archippivora,* and *Chaetogaedia monticola,* which have been reared from larvae of *V. cardui.* This statement in no way limits the number of possible parasites.

The prevalence of parasitism is shown by several of this year's reports, as follows.

"Adult emergence within (Imperial County) was much less than would appear to be indicated by the larval populations present on the desert. This was undoubtedly due to the high rate of parasitization by both insects (Tachinidae) and entomophthorous fungi." (Letter from G. D. Peterson, Jr., May 19, 1958.)

"At Topock, Arizona, on April 14 we observed relatively few butterflies but enormous numbers of Chalcid wasps which had apparently emerged in that area. These wasps were congregated around a creosote bush and several thousand were taken in a single swing of the net." (Letter from J. W. MacSwain, May 23, 1958.) The possibility is suggested that many of these may have emerged from *V. cardui* larvae and may account for the small number of adults observed.

". . . enormous numbers of hatched and parasitized pupae present at the 18 miles west of Blythe locality in late April. The

few adults present could be stragglers, late emergences, etc., which had not gone farther north yet." (Letter from J. A. Powell, May 19, 1958.)

The fact that the direction of flight of migrating *V. cardui* through California is mostly toward the north-northwest and directly against the prevailing wind has been generally observed in all the migrations on record. In the 1958 reports, this was emphasized by Dickson and Peterson in the Colorado Desert, by Dickson in describing the course taken through southern California, by Linsley, MacSwain, and Ferguson in the San Joaquin Valley, and by R. F. Smith and Swift in the Walnut Creek region. The most important variant was in the San Joaquin Valley on April 20, when the majority were flying northwest near Merced, mostly west Merced to Tracy, and mostly north west of Tracy (Linsley and MacSwain). It was not reported whether there was any difference in the wind direction between the regions just enumerated.

The author made a few observations on the direction of flight of 1958 migrants at Redondo Beach, about 1000 feet back from the ocean front. As the migrants came over singly, it was possible to follow the flight of individual butterflies. Variable winds are normal at Redondo Beach. The beach faces the west and the fair weather winds vary from northwest to southwest and on any day constantly fluctuate. The early morning winds are usually northeast, and on days of desert winds there may be northeast gusts all day. Because of the very small numbers of butterflies recorded, any conclusions as to the effect of direction of wind on direction of flight are very tentative. There was an observed tendency of butterflies to fly into the northeast wind in the morning (observed on five mornings at varying times from 7:45 to 11:20), and for the flight to be chiefly northwest, but varying slightly toward the north, during the afternoon. The limited observations support the former observations that flight, whether individual or mass, is usually straight into the wind, with little individual variation (Abbott, 1951).

A survey of collected information on the migration of *Vanessa cardui* (L.) in North America points to its classification as a unidirectional flight with no return (Williams, 1930, 1938, Abbott, 1951). Study of it in California has the special advantage that the compass direction of flight is clearly seen, the same prevailing direction occurs in every migration year, and the numbers in-

volved are great enough to insure the accuracy of these two statements.

The fact that years of general migration occur at intervals, four years more or less, supports the theory that migration occurs only when a population has been built up to what Chapman (1939) calls "outbreak proportions." Chapman describes this as resulting from a relaxation of environmental resistance. This might occur and take effect all in one generation, or it could be cumulative in result, reaching outbreak proportions after a series of generations. The occurrence of migrations at irregular intervals of years favors the cumulative interpretation, whereas a great migration in a year which is particularly favorable from an environmental standpoint indicates that it might occur in one generation.

Observations on the 1958 migration suggest another kind of cumulative result, namely, pressure of population and resulting migration continued through three generations, all of them developed under exceptionally favorable conditions. It may also be emphasized that larvae of the third generation were so numerous as to be destructive of cultivated crops.

In the reports of former years (Abbott, 1950, 1951) it was noted that the migration was in a series of waves of abundance, particularly in 1926 and 1941. It was interpreted that the flight was periodically slowed down by unfavorable weather. No data were available to show a succession of generations. Both factors were apparently involved in the 1958 season. The weather might affect metamorphosis of larvae as well as flight of adults.

Migration is only one of the results of an excessive increase in population, and why it affects only certain species has not been determined. It may be mentioned that Williams, after collecting all available information on migration of Lepidoptera, concludes that there are many more migratory species than the most abundant and conspicuous ones which are well known. He states (Williams, 1949): "We have evidence today of migration in two or three hundred species of butterflies from almost all parts of the world. In about fifty of these there is a considerable weight of evidence which makes it almost impossible to accept any other explanation." In another reference (Williams, 1957) he states that 20 or 30 migrant species are known from the United States.

SUMMARY

(1) The migration of the painted lady butterfly, *Vanessa*

cardui (L.), in California in the spring of 1958 was exceptional in its duration from November, 1957 to May, 1958, as well as in the great numbers of individual butterflies involved.

(2) The north-northwestward distribution during the period was gradual and was correlated with the development of three generations. The first generation invaded the Colorado Desert from northern Mexico from November, 1957 to January, 1958. The second generation emerged on the Colorado Desert from eggs laid by the first generation and flew north in February and early March through the San Bernardino Valley and the Los Angeles area to the Mojave Desert and the San Joaquin Valley. The third generation, emerging in the two last named regions, but chiefly in the San Joaquin Valley, resulted in a great flight through the San Joaquin and Salinas Valleys in the middle of April. The large number of larvae resulting from this third wave of the flight attacked various field crops.

(3) The continuance of a migatory flight through successive generations is favored by the fact that several widely distributed food plants serve as food for the larvae. This applies to both wild and cultivated plants.

(4) Extensive parasitism during the larval and pupal stages was noted by several observers in both the Colorado and Mojave Deserts. This furnished evidence toward the theory of Elton (1927) that parasitic attack is the most important control of an insect outbreak, whether or not accompanied by migration.

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TWO NEW RECORDS FOR THE CONE BEETLE GENUS CONOPHTHORUS HOPKINS IN CALIFORNIA

(Coleoptera: Scolytidae)

During the summer of 1956, a collection of cones of the western white pine, *Pinus monticola* Douglas was made in the Lassen Volcanic National Park area, Lassen County. Two specimens of *Conophthorus monticolae* Hopkins were reared from one of the cones. This species of cone beetle has been previously known only from the cones of the western white pine in Idaho, Washington and Canada (Keen 1958)[1]. During the same summer and following summers, collections of cones of the lodgepole pine, *Pinus contorta* var. *latifolia* S. Wats were made from several locations in the Sierra Nevada mountains. In Calaveras and Tuolumne Counties, the cones of this pine were found to be heavily infested with *Conophthorus contortae* Hopkins. Until now, this species has only been recorded from the cones of the shore pine, *Pinus contorta* var. *contorta* S. Wats near Newport, Oregon (Keen 1958). The author is indebted to Dr. S. L. Wood of Brigham Young University in Provo, Utah for the identification of these beetles.—HERBERT RUCKES, JR., *University of California, Berkeley.*[2]

1 Keen, F. P., 1958—Cone and Seed Insects of western forest trees. U.S.D.A. Technical Bulletin No. 1169. pp. 48 & 55.

2 Studies of the cone and seed insect problems of the pines in California made possible by a grant from the Gilbert M. Walker Fund.